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Why Greenhouses in the Tropics?

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1 Introduction.

The cultivation of vegetables in the Tropics is very important as a source of fresh food, vitamins and income for the population. The temperatures and the global radiation are very suitable for vegetable production in tropical countries throughout the year, but open air cultivation is severely hampered, mainly by heavy rainfall and high humidity. Heavy rainfalls can damage the crop and the infestation by diseases is caused by high humidity and rainfall, and the consumption of pesticides increases. Many projects have been started on so called IPM (Integrated Pest Management). Not only IPM but ICM (Integrated Crop Management) or IPP (Integrated Production and Protection systems) will be necessary in the future.

The main question is: How to produce more clean vegetables at better quality with less pesticides, with less water and with less land.

One answer and one component for integrated production systems is:

The development and use of efficient but cheap technologies for protected cultivation in adapted protective shelter/structures. That means not imported greenhouses from countries with subtropical or temperate climate, but the design of constructions which are adapted to local climates and fabricated with locally available materials, as far as possible.

2 Advantages of Tropical greenhouses

The vegetable production under adapted greenhouses results in:

- Higher yield with better qualities.
- Reduced risks for quality and yield.
- Less susceptibilities to diseases because of less wetting and damage by heavy rainfall.
- Extending of harvest time.
- Reduced water consumption.
- Better use of fertiliser and pesticides..
- The methods of Integrated Crop Management can be better applied under protected cultivation.

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The following figures for the yield of tomatoes (variety Capitan) were measured in a FAO-project in Seychelles during the wet season from November to April (PRUDANCE, in FAO 1997):

Open field: 2.9 kg/m^2

Greenhouse: 6.5 kg/m^2

3 Design criteria for Tropical greenhouses

The climate conditions of a region have to be investigated and compared with the main requirements for plant growth, to test the suitability for crop production under shelters and to develop suitable constructions. The main criteria for adapted greenhouses are:

- The demands for plastic film structures.
- The climatic conditions in the region.
- The locally available materials.

The main influencing characteristics in tropical humid climates are:

- High monthly precipitation with heavy rainfall during the wet season.
- High mean air humidities of nearly one hundred per cent on cloudy days, and in the morning and evening.
- Little temperature variation throughout the year and relatively little temperature difference between day and night.
- Steady mean daily global radiation throughout the year but high irradiation at noon because of the short day-length.
- Temperatures are above the biological minimum of the crop throughout the year
- Frequent tropical storms and tropical cyclones.

Greenhouse shelter/structures for tropical climates should have the following characteristics:

- Crop protection from rain, wind and too high global radiation.
- Very efficient ventilation. Ventilation openings in side walls and the ridge. Ridge ventilation is absolutely necessary.
- The relation of greenhouse volume to ground-floor area should be as large as possible. The gutter bight should be at least 3 m. The higher the structure with ridge ventilation, the higher the ventilation efficiency by the chimney-effect.
- Gutters are necessary to drain off the rain-water and to prevent the rain-water from penetrating the greenhouse.
- Resistance of the construction for wind and crop loads.
- Foundation constructions should guarantee wind resistance and should prevent stanchions from corrosion or rotting.
- If necessary ventilation openings have to be equipped with nets to protect against birds and insects but the ventilation efficiency should not be affected too much.
- Film destruction by fluttering in the wind has to be avoided. The film must not flutter, but has to be stretched tightly by simple stretch devices.

- Simple methods to change the film especially in regions with high labour costs.
- Water-saving irrigation systems should be used to avoid the increase of air-humidity.

4 Examples of Tropical greenhouses

Growers use simple structures covered with branches in several countries, mainly in south-east Asia, (Fig. 1). Fig. 2 shows simple tunnel constructions, covered with plastic nets. Those structures protect the crop from too high radiation, but they are permeable to rainwater and do not protect the crop from being wetted by rain and infested by diseases. it is more advantageous to use plastic-film covering for an integrated crop production system.

Fig. 1: Simple protective shelter structure, covered with branches in Vietnam.

Fig. 3 shows some principle shapes for tropical greenhouses. All of them have ridge or roof ventilation. Side-walls and gables should be closed by a 50 to 60 cm high plastic-film close to the soil. The plastic-film can be buried in the soil and fixed at the structure by stretched wires. Thus water cannot penetrate side-wards into the structure. The ridge ventilators of the constructions **a** to **d** have a better ventilation efficiency than the structure **e**. A vertical opening allows better air exchange through the whole structure by suction and pressure forces of the wind. The structure **e** has less ventilation efficiency by the chimney-effect. The wind blows straight through the two openings at the ridge. If the roof construction is made of steel pipes, a round arched structure is recommendable like **d**.

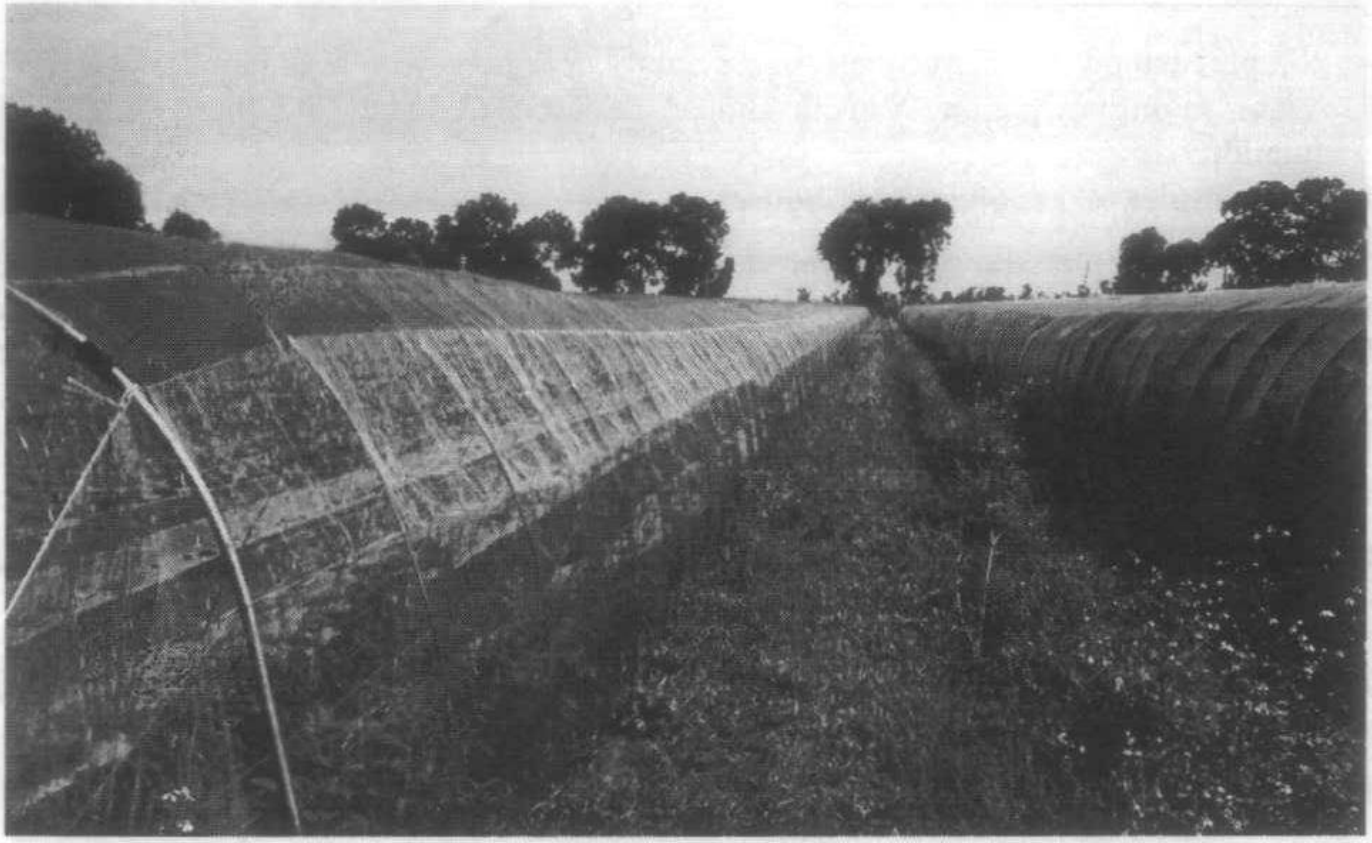

Fig. 2: Simple tunnel-construction, covered with nets in Vietnam.

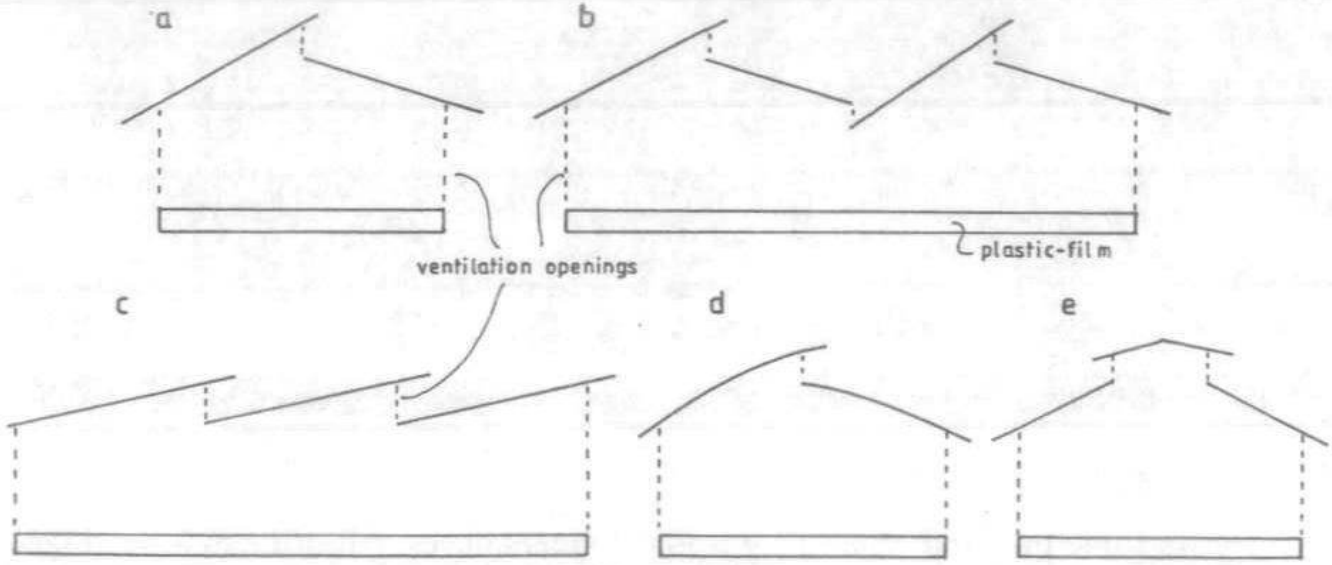

Fig. 3: Principle shapes for Tropical Greenhouses.

The advantages of greenhouses for tropical regions were investigated and proved in a FAO-project carried out on Seychelles from 1993 to 1996. Meanwhile, many farmers have built greenhouses for vegetables and achieved very good results and profits. (FAO, 1997)

Fig. 4 shows an example of a saddle-roof construction designed from timber profiles for the experimental station in Seychelles. The width of the structure is 6 m, the distance of the stanchions should be not more than 2.5 m. The diagonal windbraces are

absolutely necessary at both ends of the side walls for the stabilisation against wind-forces in longitudinal direction. The vertical stanchions should be fixed in steel supports, which are put into steel foundations. A plastic film of about 50 cm height is fixed at the side-walls near the ground. The plastic-film is buried in the soil and the little ditch is filled with gravel. In this way it serves as a gutter and stabilisation against wind forces.

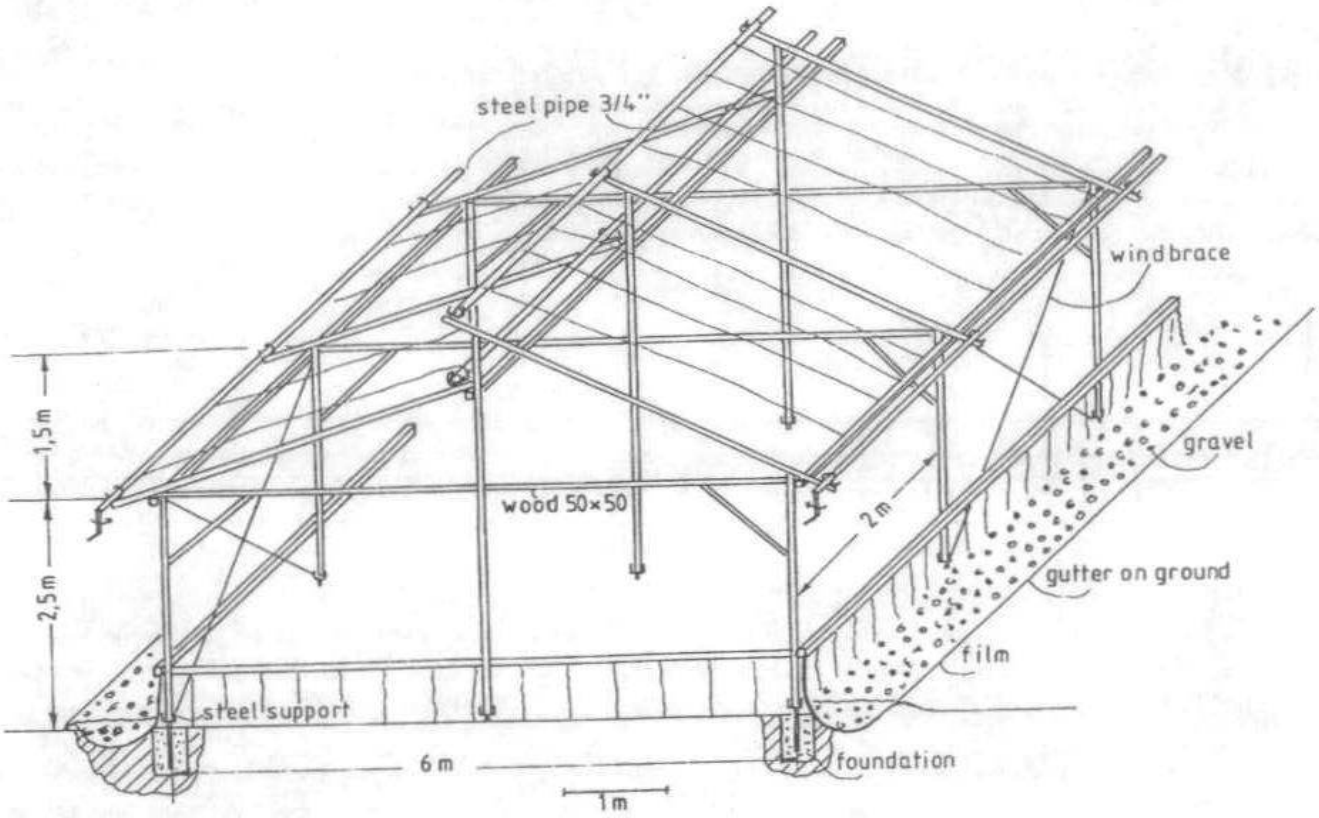

Fig. 4: Wooden construction, designed for Seychelles.

Fig. 5 shows a multispan greenhouse, designed also for the experimental station in Seychelles. Fig. 6 shows a new multispan greenhouse, built by a grower on a farm. In this case the grower adopted some of the proposed ideas. Many growers built simple constructions by themselves, which show, in principle, very good designs, (Fig. 7 and Fig. 8), but some of them still have some disadvantages. The construction in Fig. 7 is covered with plastic films, which are stretched in a longitudinal direction on a wooden structure. There is a space between the films for ventilation. The ventilation efficiency is good, but the edges of the plastic are not fixed in longitudinal direction and can flutter by wind forces. The structure, shown in Fig. 8 is a relatively light construction, but the wind-stability may not be high enough. There are no ventilation-openings in the roof area, and therefore the ventilation efficiency is insufficient. The main idea is to build cheap constructions. One should take into consideration the design criteria and the main characteristics for tropical greenhouses and build efficient and cheap greenhouses.

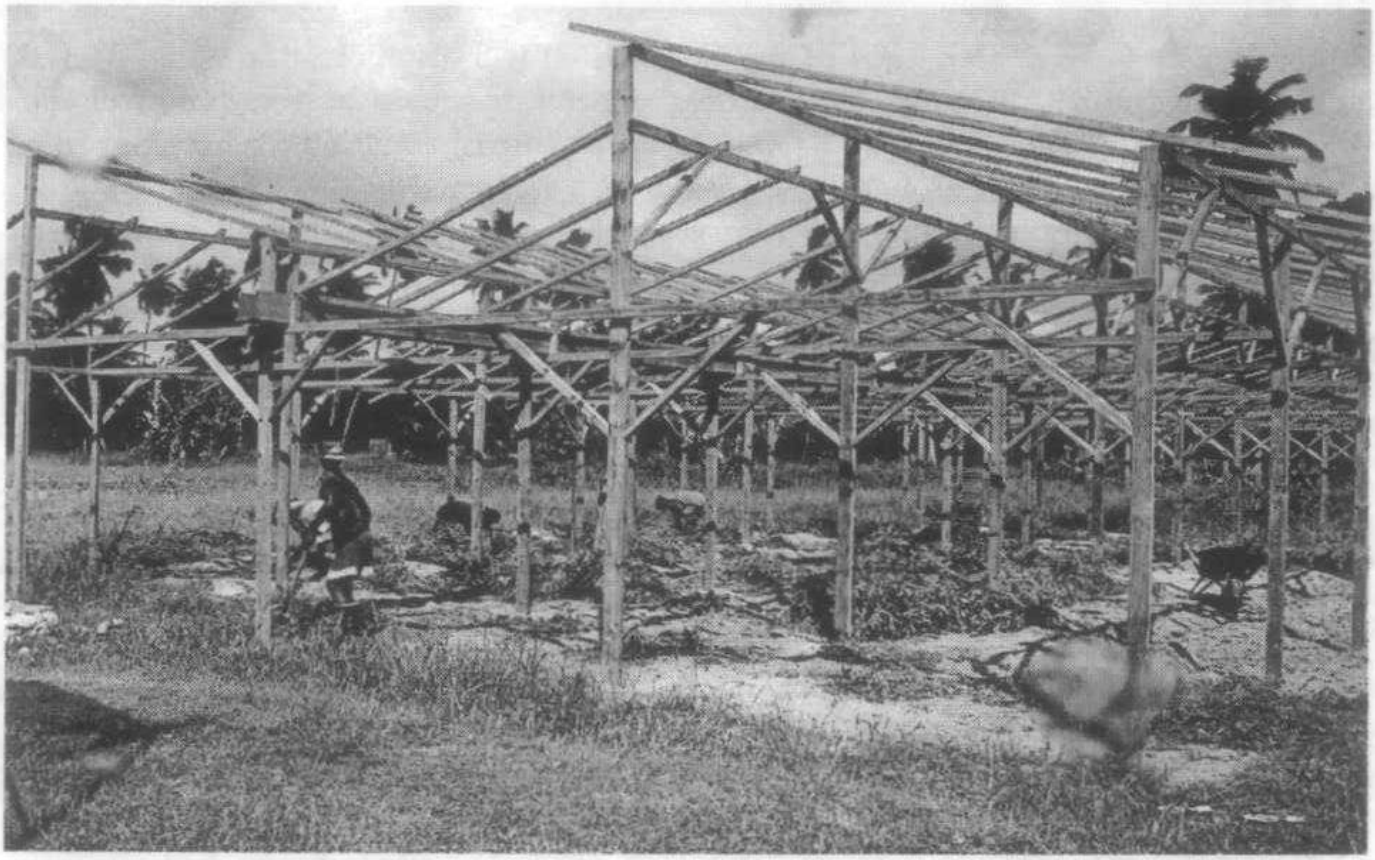

Fig. 5: Multispan greenhouse, designed for Seychelles.

Fig. 6: Multispan greenhouse on farm.

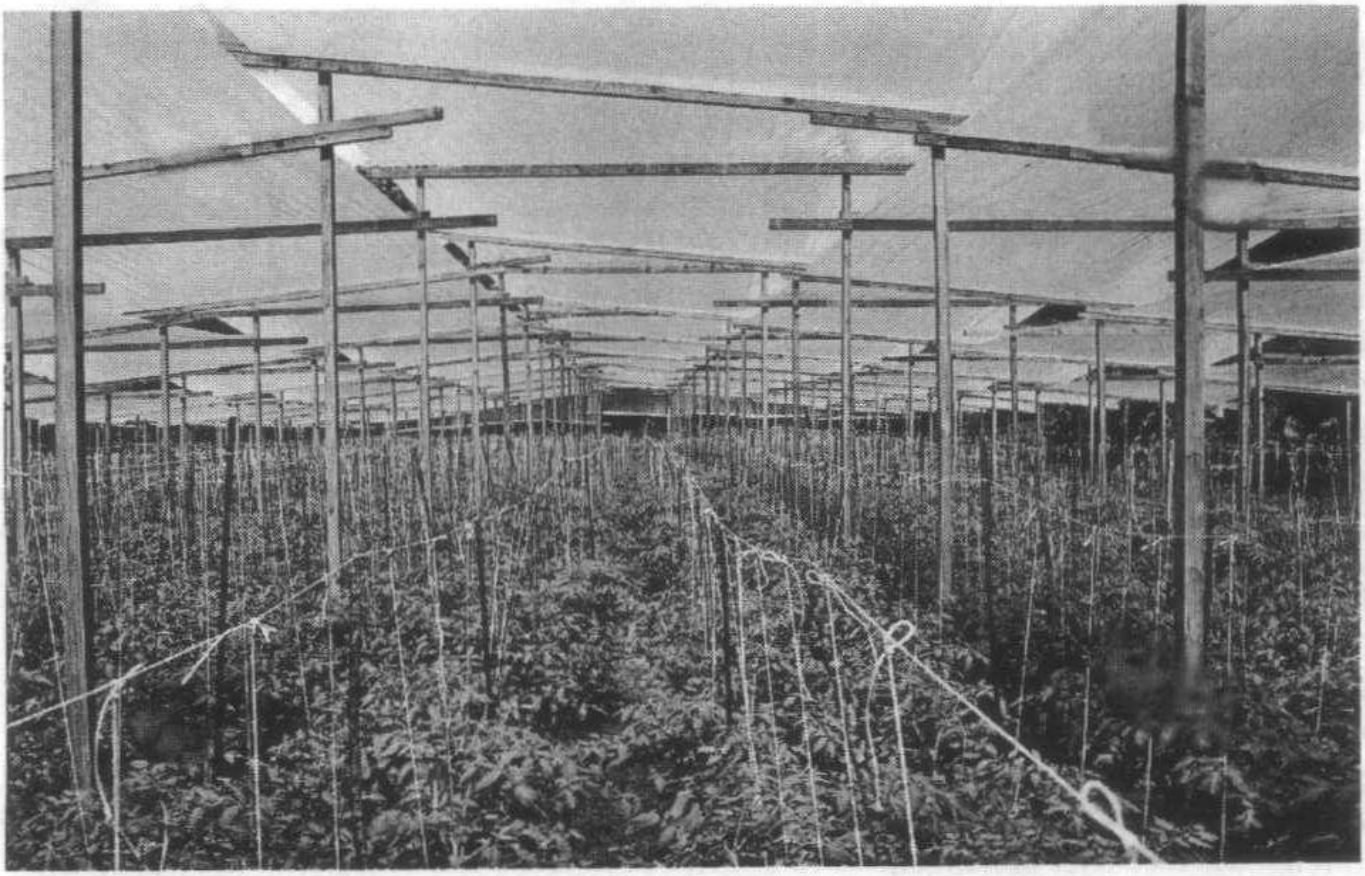

Fig. 7: Wooden construction, designed by a grower in Seychelles.

Fig. 8: Greenhouse on farm without ridge ventilation.

5 Summary

Greenhouses for vegetable growing in tropical Climates have remarkable advantages in comparison to open field production, for example higher yields, improved quality, less water consumption and reduced losses of fertilisers and pesticides. The main design criteria which depend on the climate conditions of the region, the locally available materials and the general demand for plastic film greenhouses are discussed. Examples of newly designed greenhouses and of constructions on farm are discussed with their advantages and disadvantages.

Warum Gewächshäuser für die Tropen?

Zusammenfassung

Gewächshäuser haben im Vergleich zum Anbau im Freiland erhebliche Vorteile für die Gemüseproduktion in den Tropen, beispielsweise höhere Erträge, bessere Qualität, geringeren Wasserverbrauch und weniger Verluste an Dünger und Pflanzenschutzmittel. Die wichtigsten Konstruktionskriterien, die von den lokalen Klimabedingungen, den am Standort verfügbaren Materialien und den allgemeinen Anforderungen für Foliengewächshäuser abhängen, werden diskutiert. Beispiele von neuen Gewächshauskonstruktionen und von Gewächshäusern in Produktionsbetrieben werden mit Vor- Nachteilen dargestellt.

6 Reference

1. FAO, 1997, Handbook on improved vegetable production technologies in the Seychelles. Final reports on the FAO-project: Improved vegetable production in Seychelles. In print.